The Proposed DESDynI Array-Fed Reflector Feed

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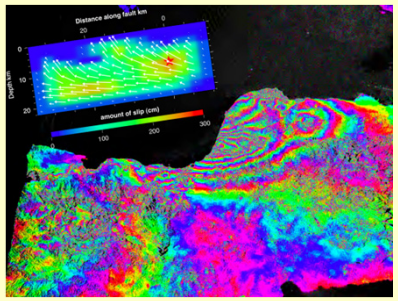
Outline

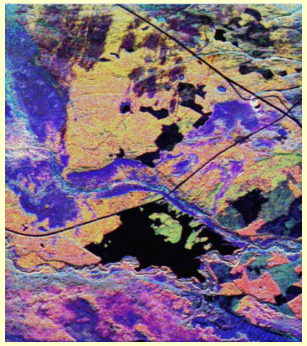
- Overview
  - Proposed Mission
  - Proposed Instrument
  - SweepSAR Concept
- Proposed Array-fed Reflector Design
  - Reflector and Feed Configuration
  - Feed Antenna Tile
- Predicted Performance
  - Modeling
  - Patterns and Gain
- Conclusions

Proposed DSAR Mission Overview

DSAR: DESDynI*SAR*

Deformation
Ecosystem
Structure
Dynamics of Ice
Synthetic Aperture Radar





Proposed Mission Objectives:

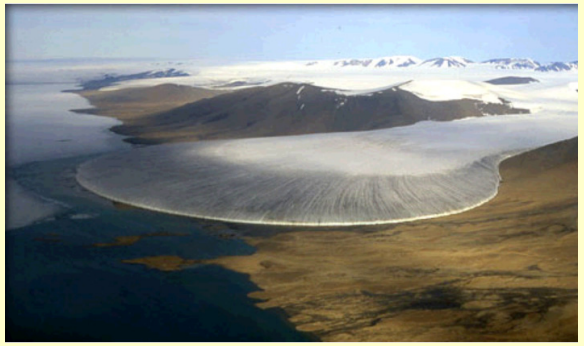
- Determine likelihood of earthquakes, volcanic eruptions, landslides
- Predict response of ice sheets to climate change & impact on sea level
- Characterize effects of changing climate & land use on species habitats & carbon budget
- Monitor migration of fluids associated with hydrocarbon production and groundwater

Constraints:

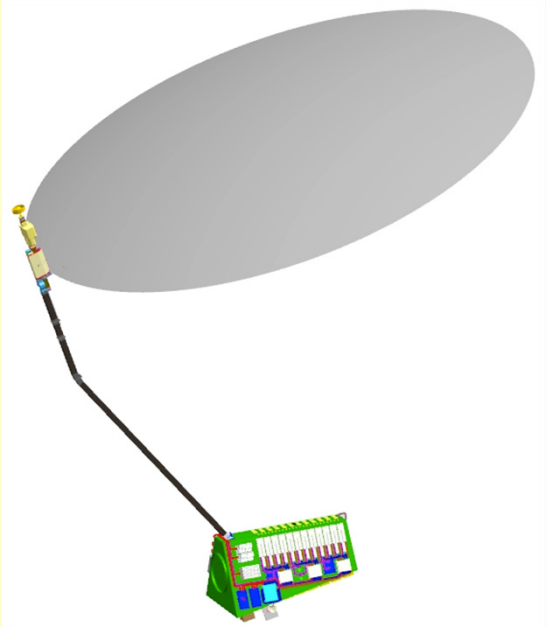
- Single Radar instrument
- NASA cost-constrained (has been driving design)

Status:

- Currently in pre-Phase A studies
- TBD launch



Proposed Instrument Overview



Interferometric Synthetic Aperture Radar

Deployable Mesh Antenna

Patch Array Antenna Feeds

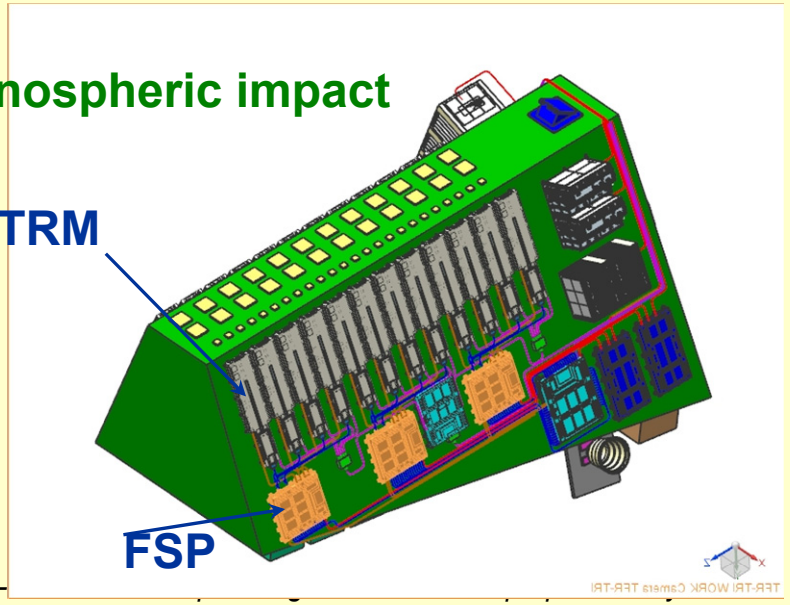
***SweepSAR* asymmetric Transmit and Receive**

Transmit Receive Modules (TRMs)

Front-Side Processors (FSPs)

Digital Beamforming on Receive

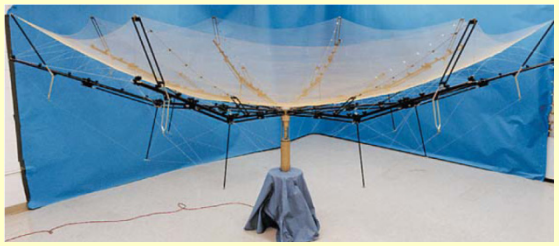
- **L-band for decorrelation**
- **S-band for sensitivity & lower ionospheric impact**
- **Quad-pol for biomass**
- **Short repeat intervals**
  - **12 day equator**
  - **3 day ice caps**
  - **232km swath (quad-pol)**
  - **12m resolution**



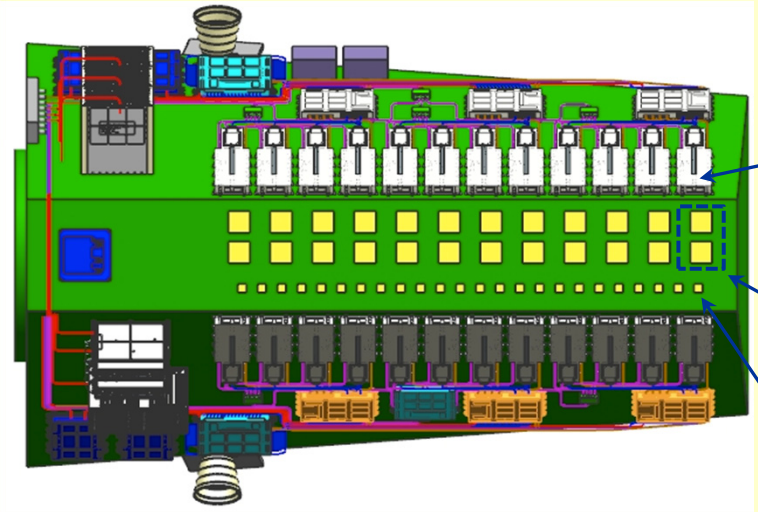
Proposed Antenna System

"The DESDynI Synthetic Aperture Array-Fed Reflector" IEEE Array 2010

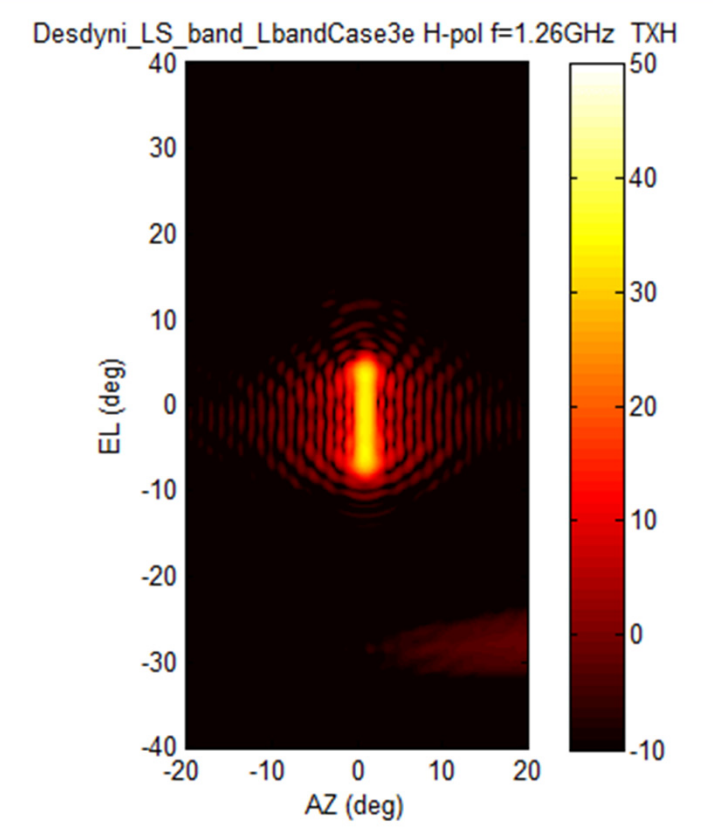
- **Deployable mesh antenna**
  - 12m projected diameter
  - Northrop AstroMesh or Harris Deployable Truss
  - High mass efficiency: 1.0 – 1.5 kg/m^2
  - High TRL with many successful deployments
- **Array feed**
  - 12x2 dual-pol L-band (1.26 GHz) patch elements
  - 24x1 dual-pol S-band (3.20 GHz) patch elements
  - Separate TRMs for H-pol and V-pol
  - 3.1m length support structure

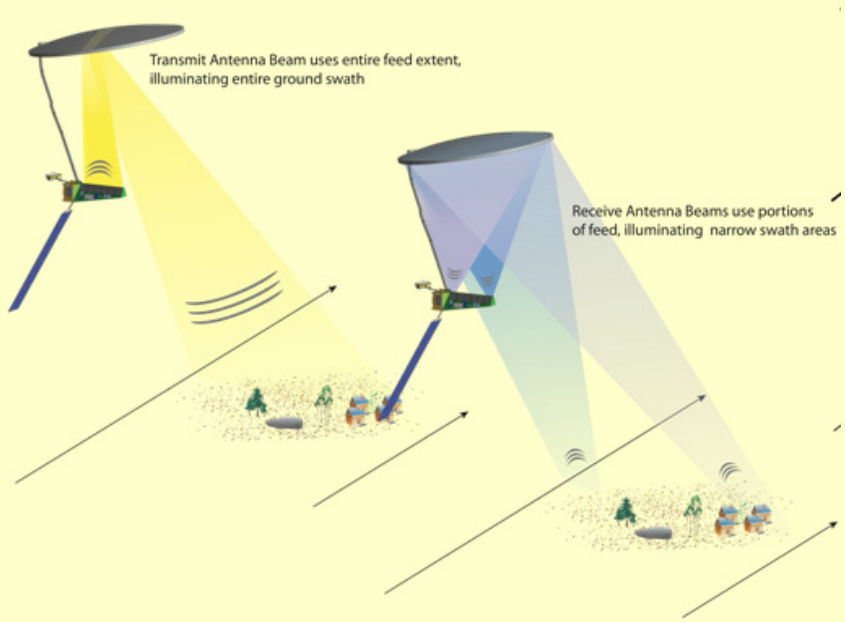


Artist's Concept



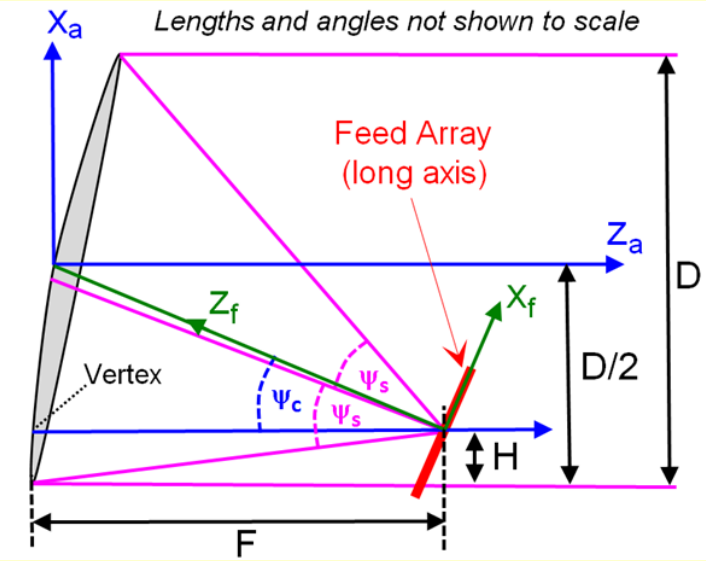
Proposed Sweep-SAR Concept





- On transmit, all feed elements are excited simultaneously, under illuminating the reflector resulting in a broad beam in elevation
- On receive, signals at individual elements are processed sequentially as they are received, sweeping across TX footprint

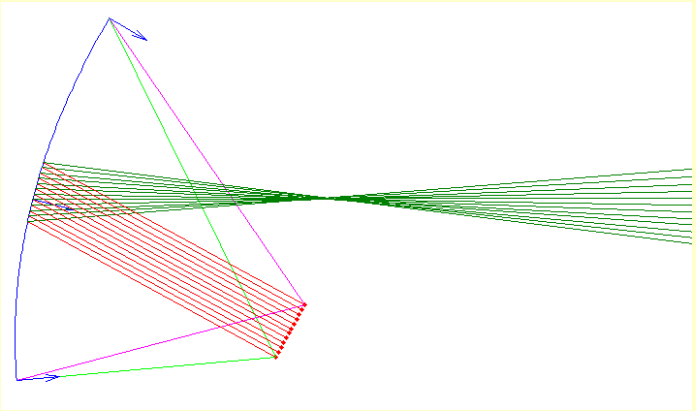
Proposed Antenna Optics and Performance



12m Diameter Prescription

Parameter	Description	Value
D	Projected aperture	12 m
F	Focal Length	9 m
H	Edge offset	-1.4m
Ψ_C	Center angle	29°
$2\Psi_S$	Subtended angle	70°

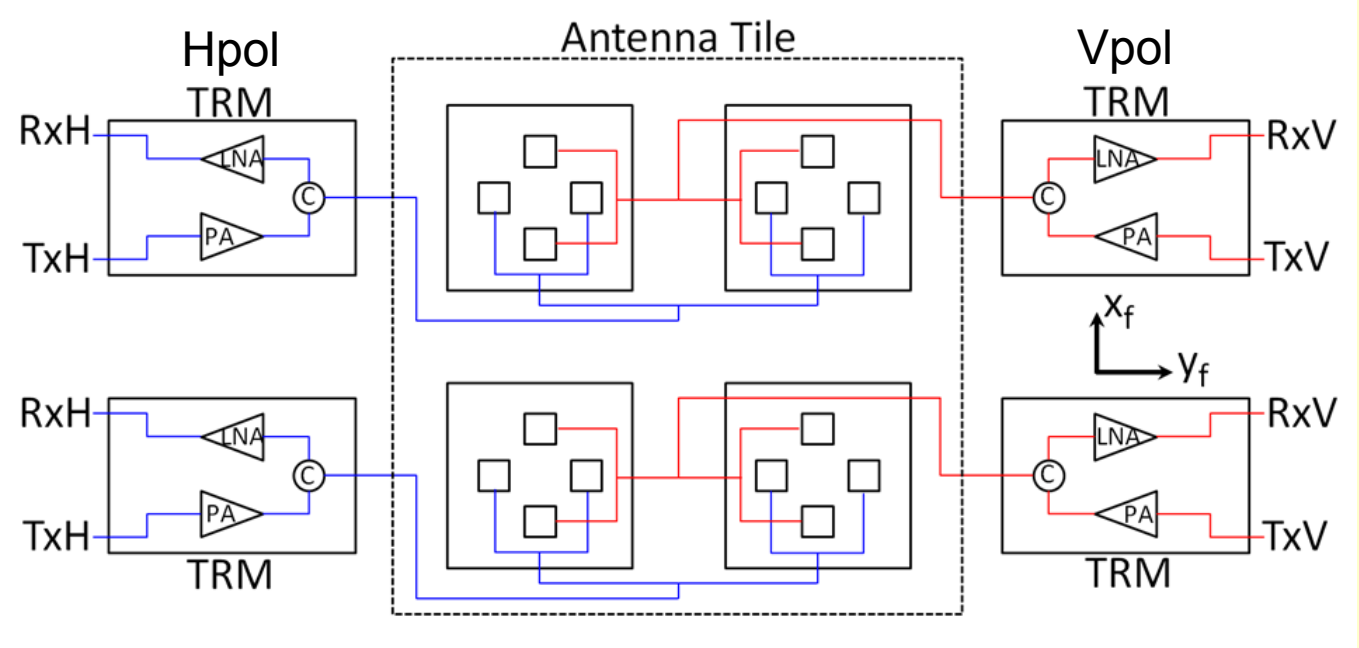
Elevation Scanning



Nominal L-band Performance

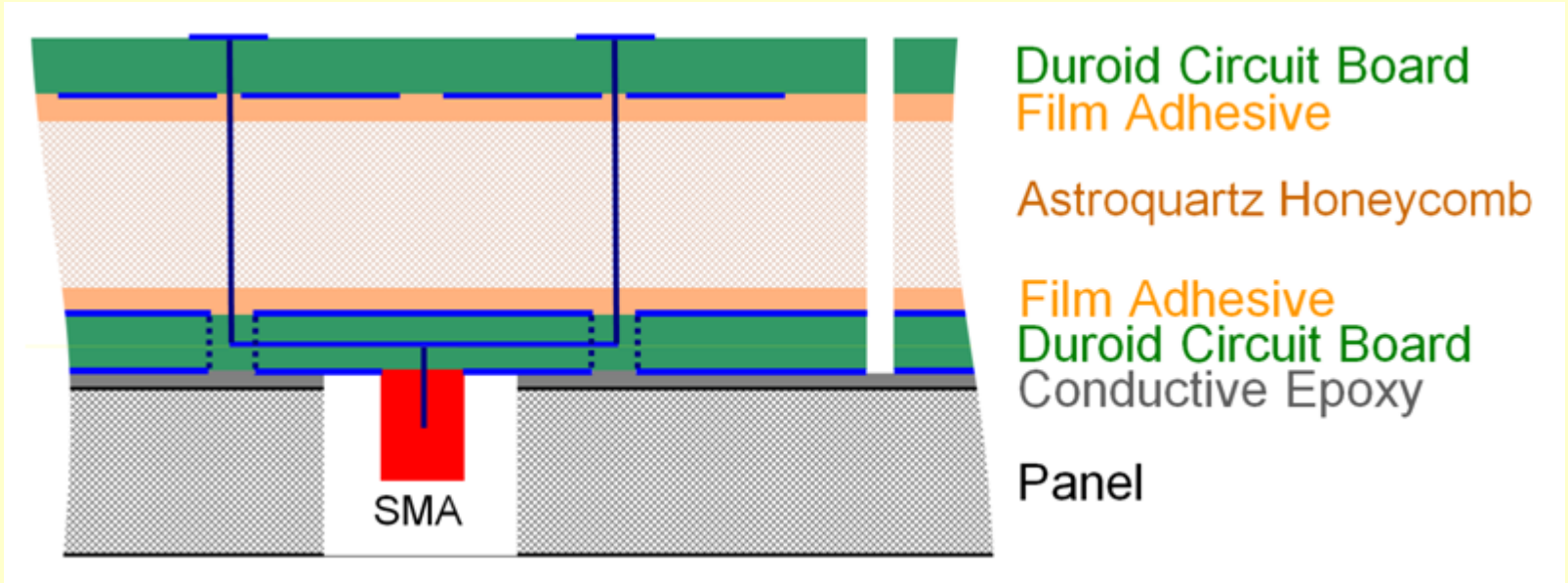
		Tx	Rx
Scan range	deg	N/A	-7°→+4°
Directivity	dBi	34.0	41.5
Loss	dB	1.7	1.7
HPBW az	deg	1.2	1.2
HPBW el	deg	11.6	1.2
Cross Pol	dB	-25	-25
EIRP	dBW	63	N/A

Proposed L-band Feed Configuration



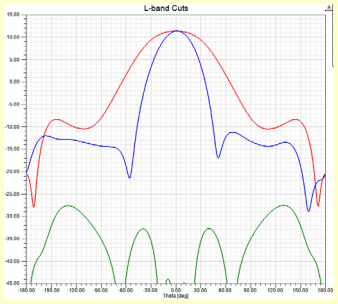
- 2x2 tile of dual-probe-fed dual-polarization patch elements
  - 18cm elevation spacing (Xf), 13cm azimuth spacing (Yf)
  - Concatenated 6 times in elevation to form feed array
  - Dual probes fed in anti-phase to improve pattern symmetry and reduce cross-pol
- Tiles have integrated stripline feed circuits to split/sum signals
- 100W Transmit / Receive Modules (TRMs)
  - Separate TRMs for H-pol and V-pol eliminates polarization switch

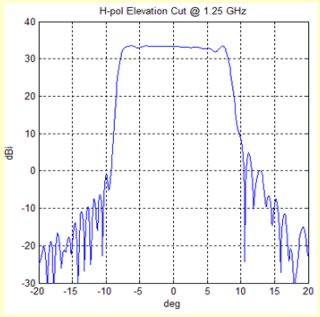
Proposed Antenna Tile Construction



- Composite 18mm thick Astroquartz honeycomb Duroid tile assembly
  - Bonded using film adhesive in a high temperature cure
- Excellent RF performance and low coefficient of thermal expansion (CTE)
  - Proven performance and durability, as demonstrated on UAVSAR
- Stripline circuit board is fabricated using a fusion bond
  - Circuit traces are fenced with vias to ensure good isolation
- Probe interconnects couple capacitively from the patch to the stripline feed

Modeling The Proposed Antenna





HFSS
FEM

Element Patterns

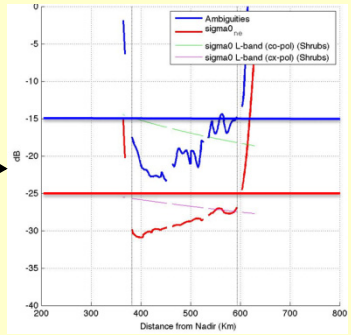
MATLAB

GRASP
PO/PTD/MOM

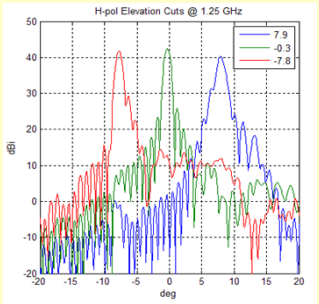
Tx Patterns

Rx Patterns

Radar
Scattering

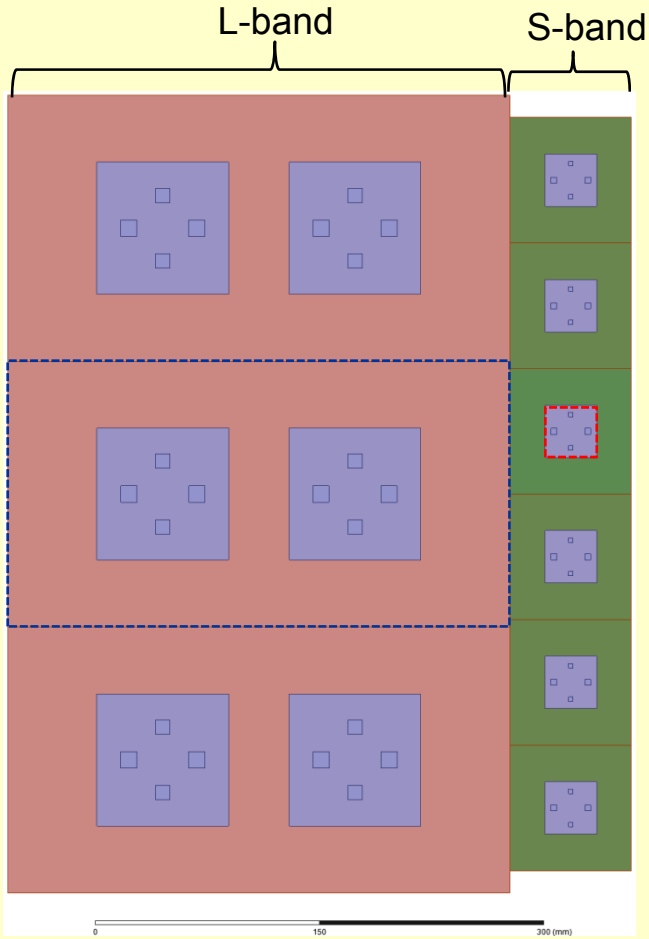


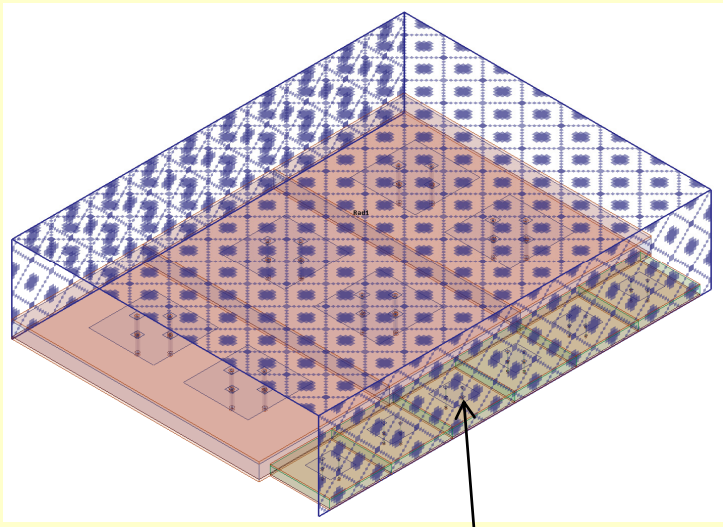
Sensitivity & Ambiguity versus range



- Generally don't model entire feed in HFSS
- Stripline feed modeled in HFSS but generally not included in pattern synthesis
- Do not model loss, mesh, or faceting in GRASP
  - Sometimes do not include support structure and boom

Proposed L-band/S-band Feed Model



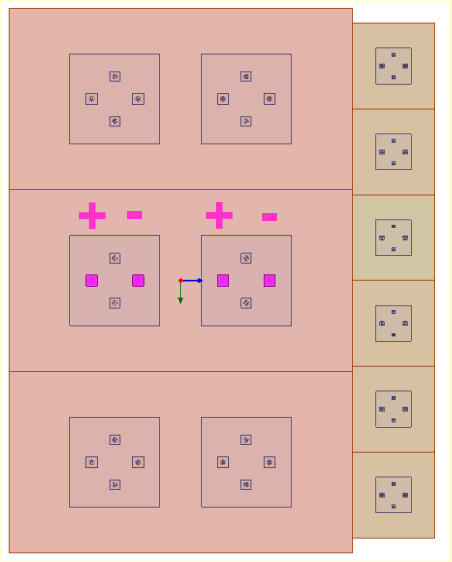


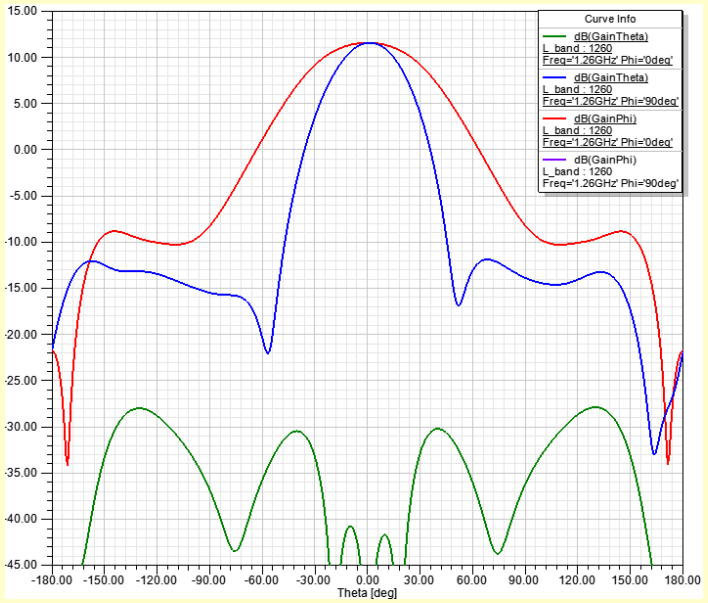
- HFSS model has radiation boundary spaced min. ¼ wavelength (shown on 3 of 5 sides of solution box)

- S-band elements offset in azimuth to reduce mutual coupling to L-band elements
  - Causes secondary pattern to squint in azimuth assuming neither feed is on focus
- Surrounding elements provide the good approximation to local BC
  - Typical pattern taken from middle elements (shown with dashed boundary)

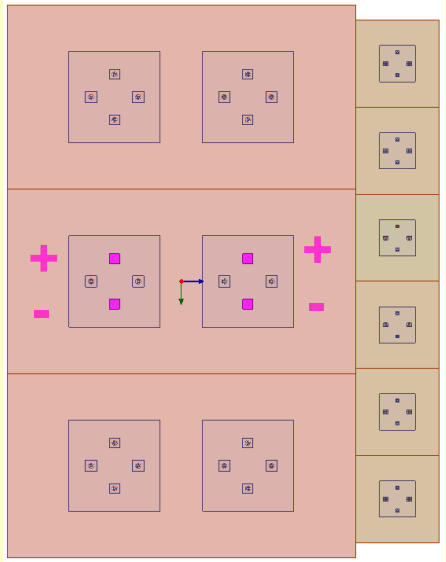
Synthesized L-band Feed Patterns

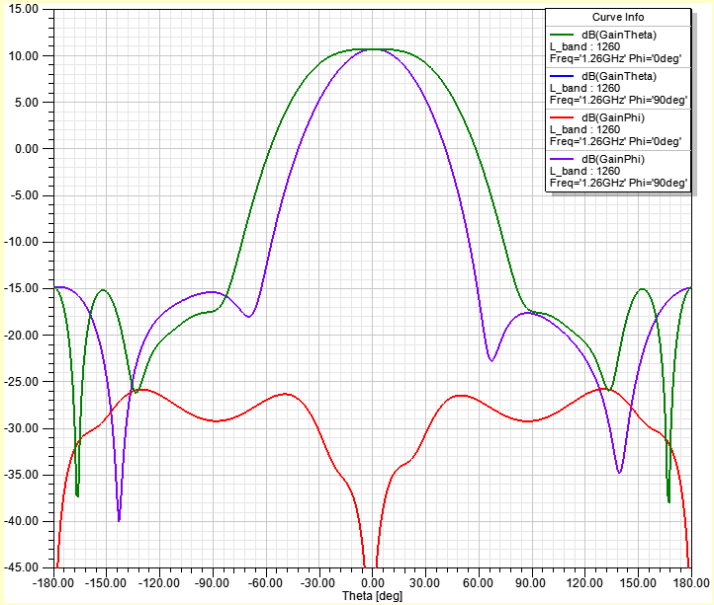
H-pol





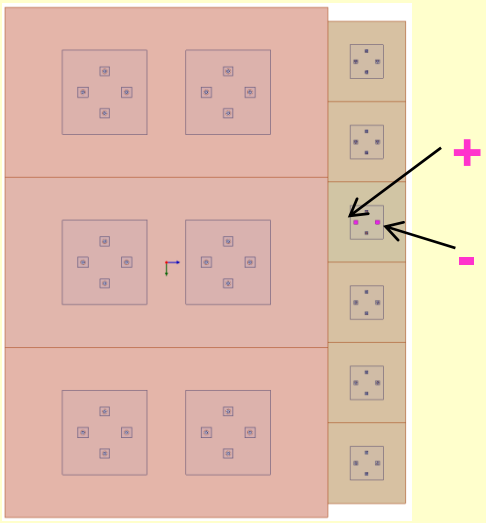
V-pol

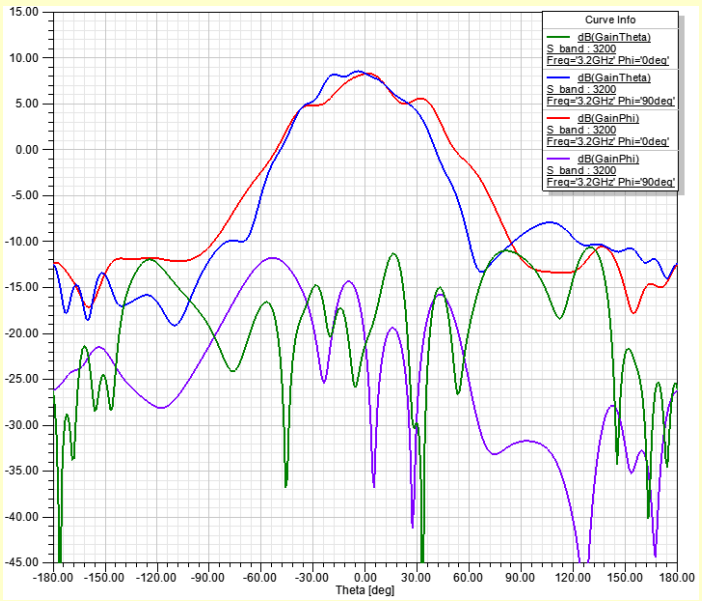




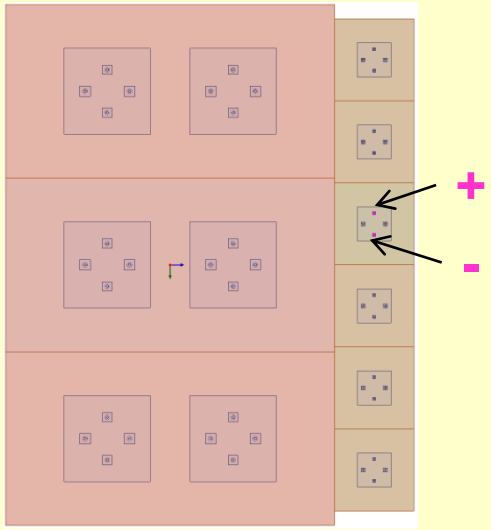
Synthesized S-band Feed Patterns

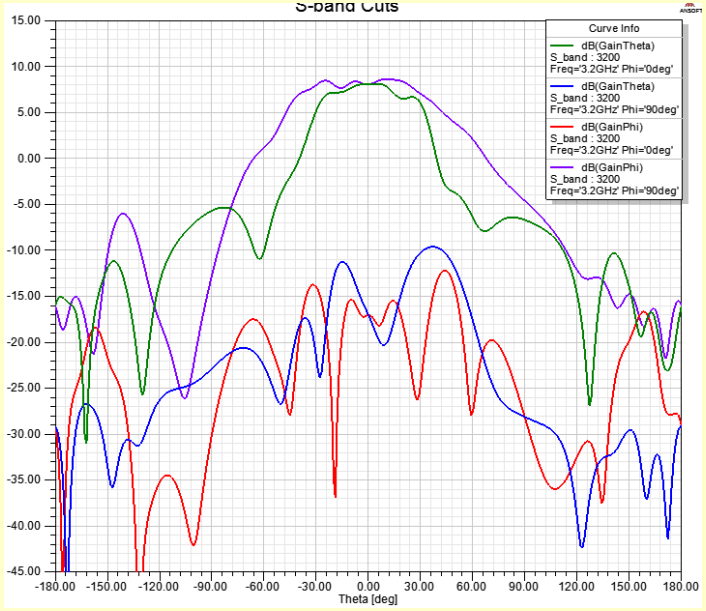
H-pol



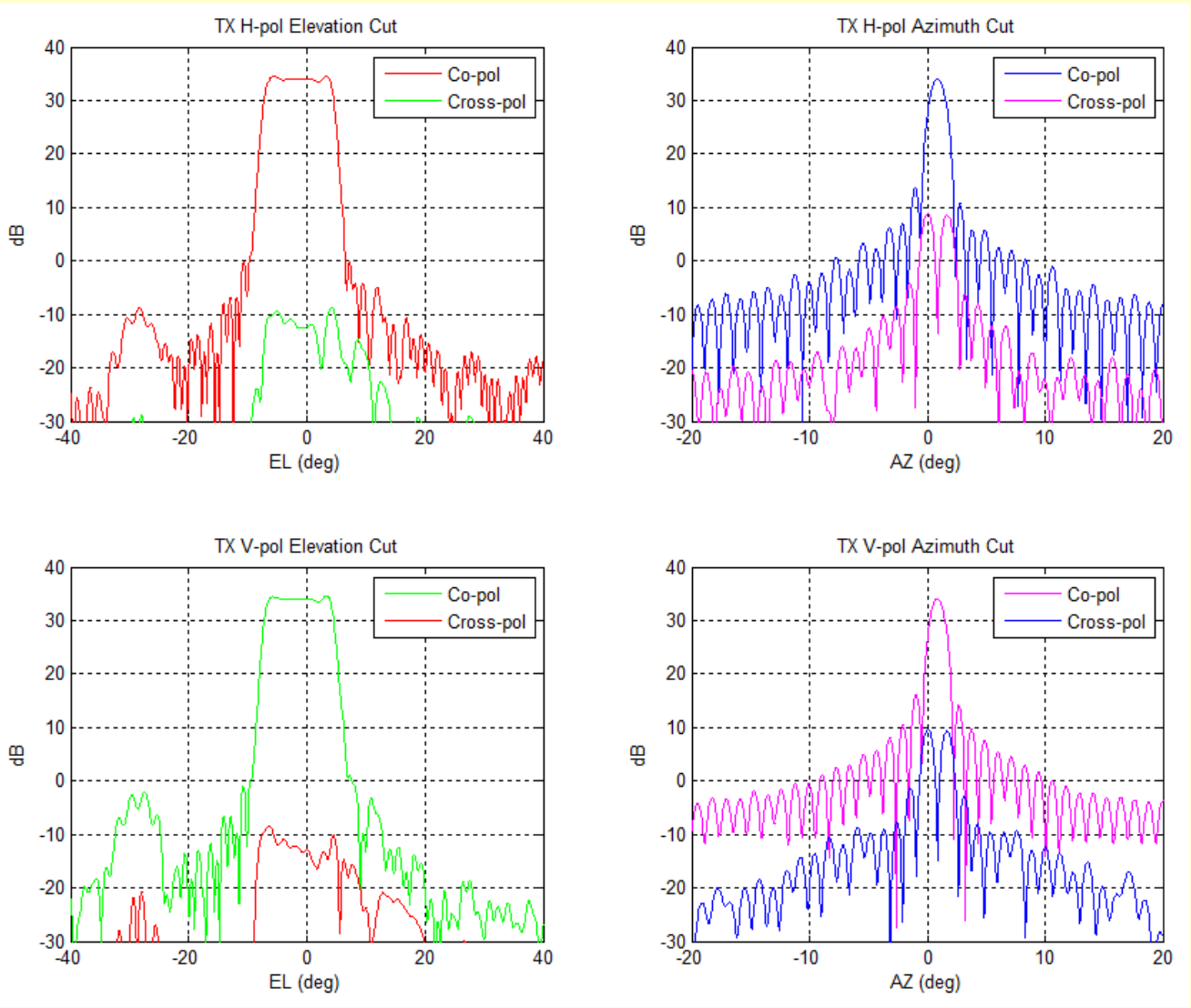


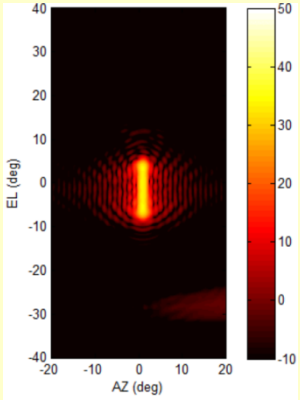
V-pol



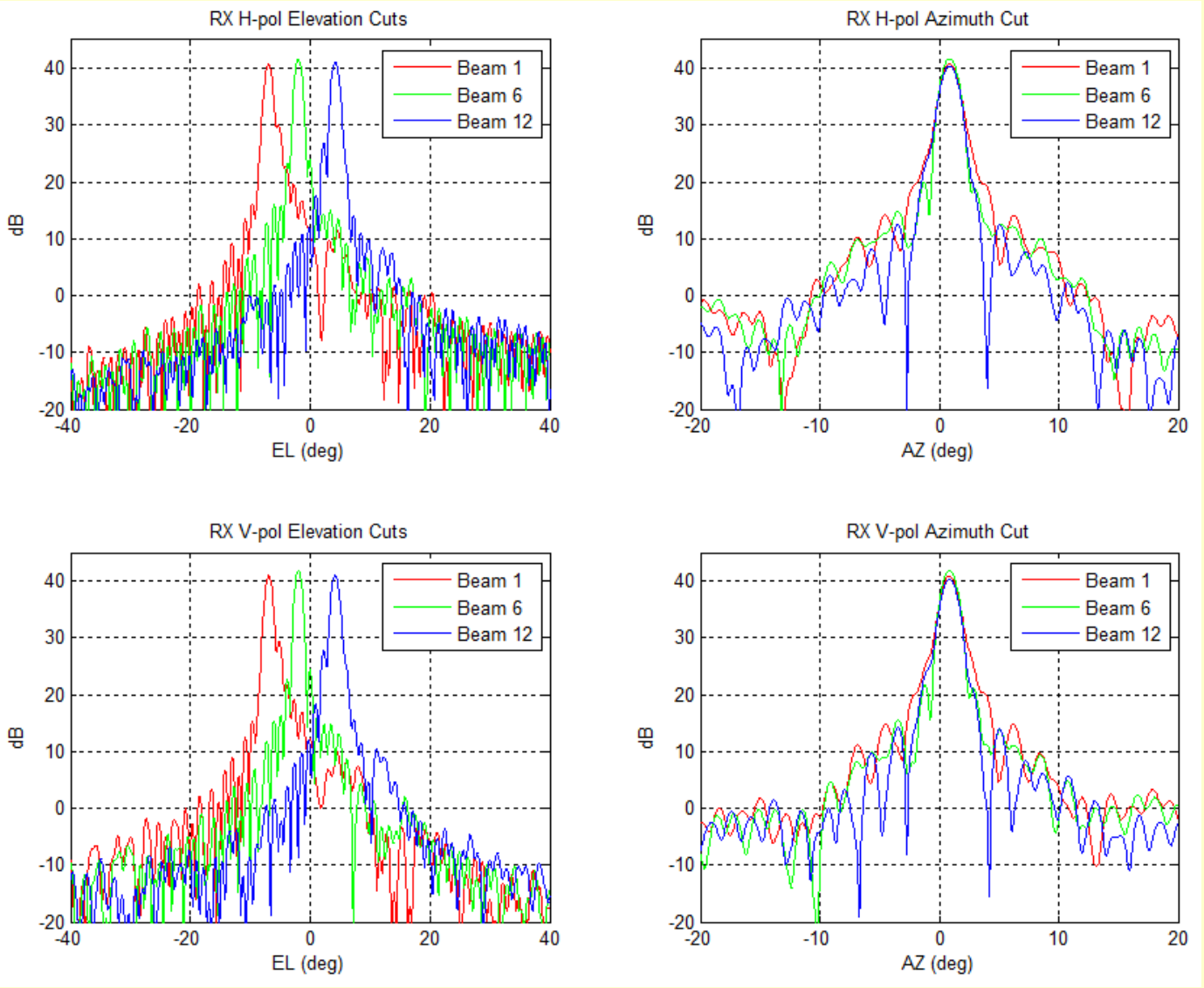


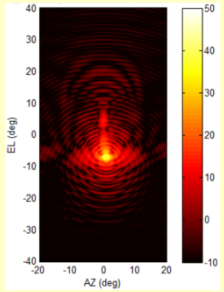
Synthesized L-band TX Secondary Patterns

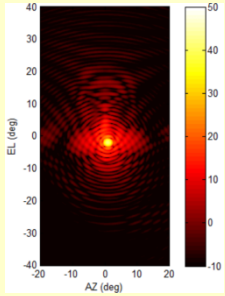


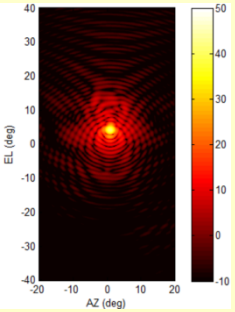


Synthesized L-band RX Co-pol Secondary Patterns

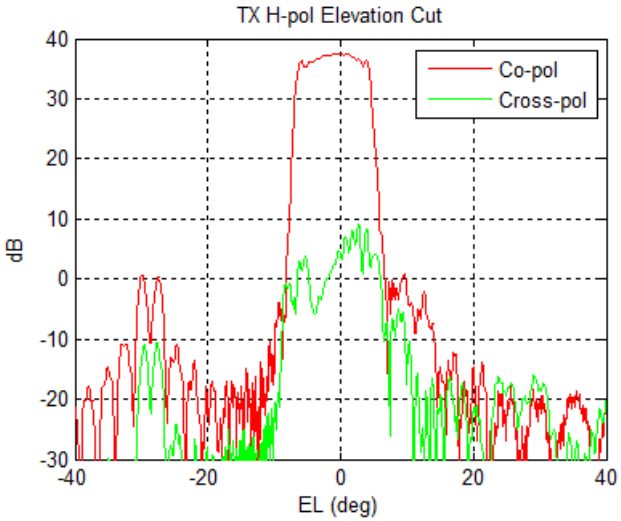


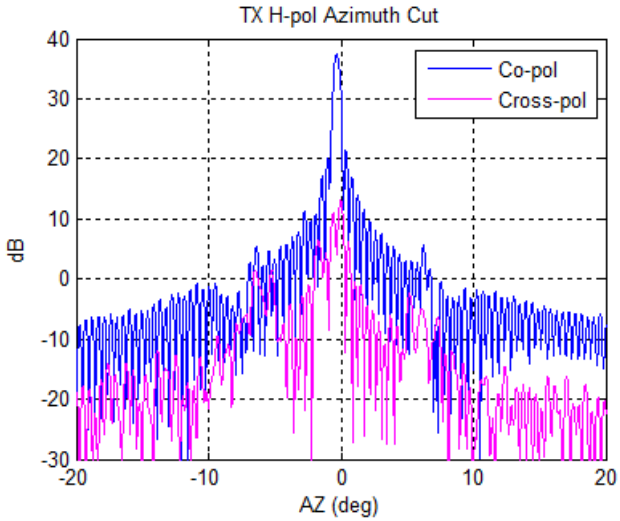


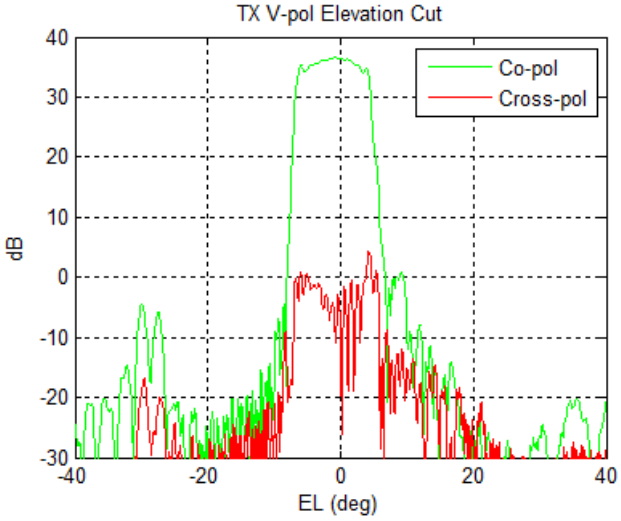


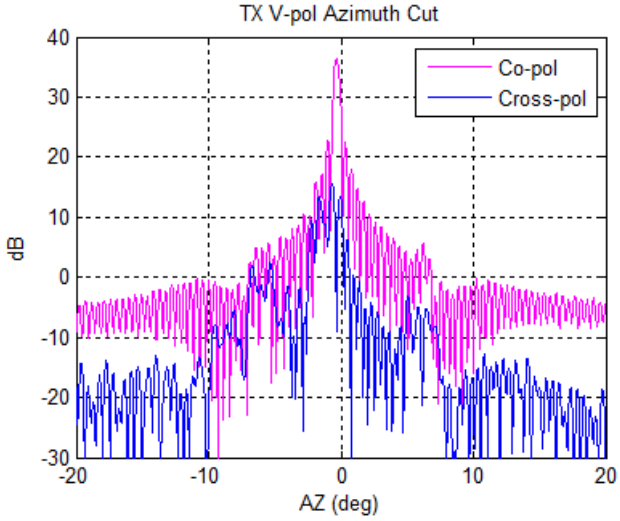


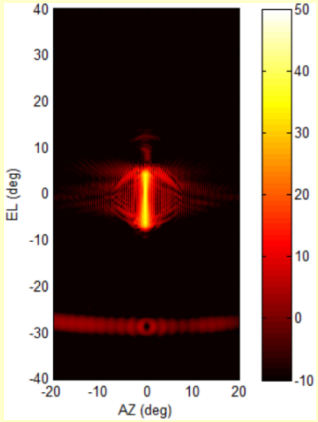
Synthesized S-band TX Secondary Patterns



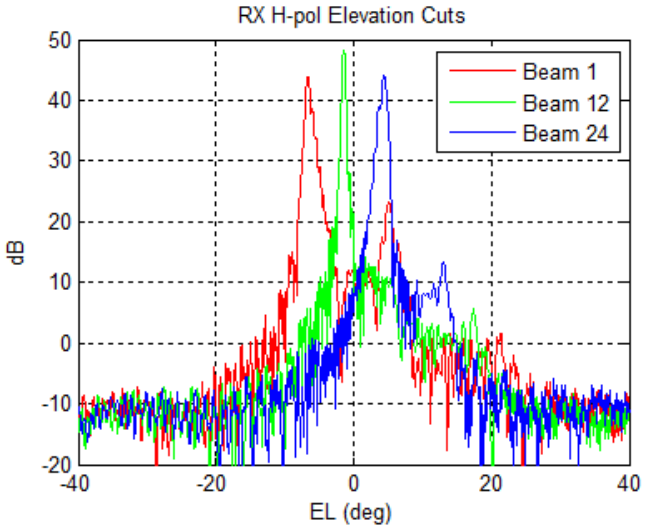


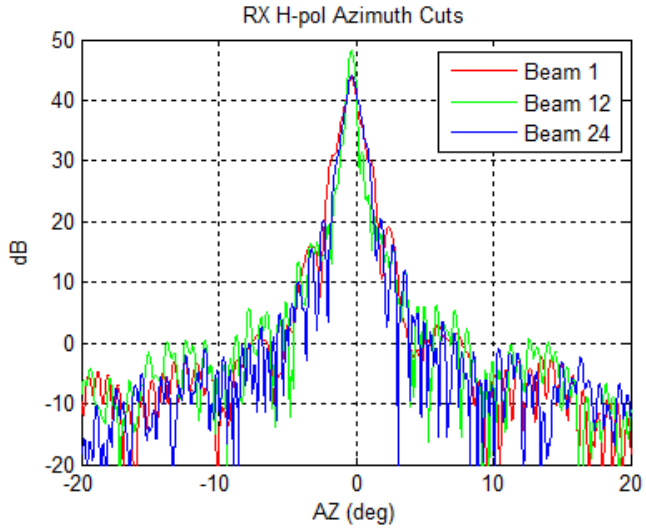


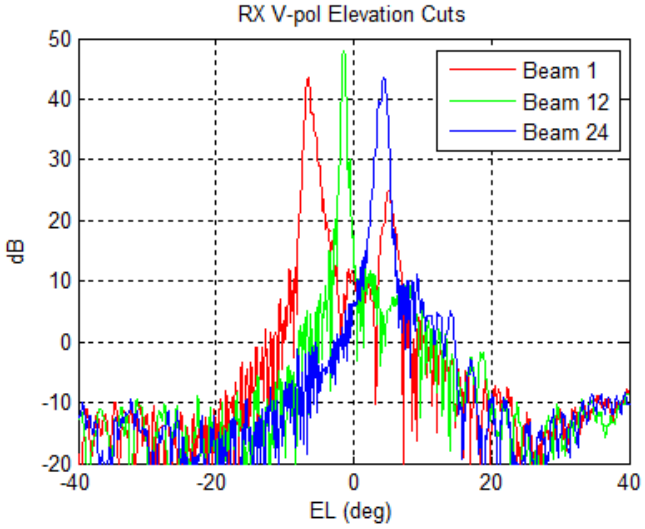


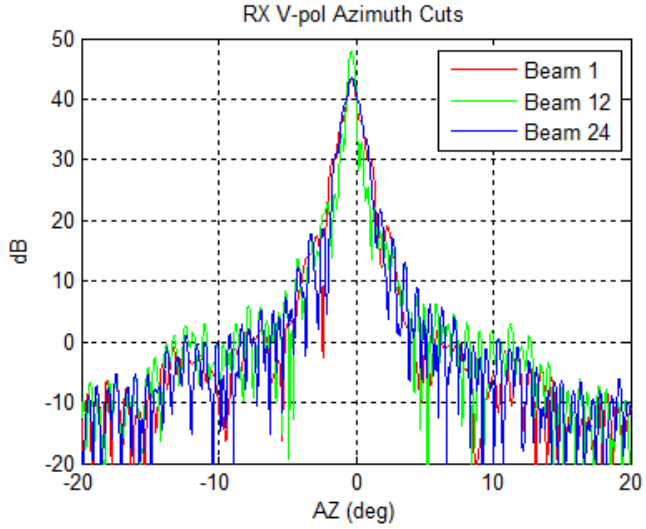


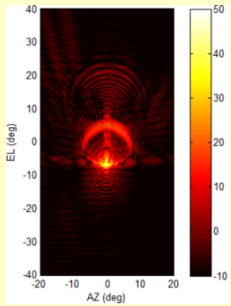
Synthesized S-band RX Co-pol Secondary Patterns

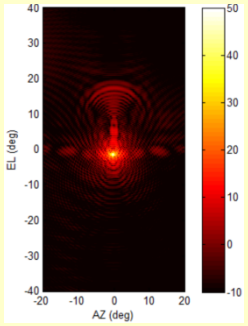


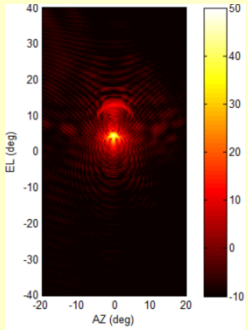












Concluding Points

- Proposed DESDynI Synthetic Aperture Radar (DSAR) Mission:
  - Monitoring climate change, predicting earthquakes and volcanoes
- Interferometric SweepSAR with Digital Beamforming
  - Asymmetric ‘all on’ transmit versus sequential receive
  - Obtains wide swath with low repeat interval
- Array-fed reflectors:
  - Mass and cost-efficient large-aperture scanning antennas with high TRL
  - Limited scan capability relative to phased array but sufiicient for proposed mission
- Patch Array Feed:
  - Low-profile, low-mass design that can readily adapt as design evolves
  - Proven design approach from previous missions, including UAVSAR and Deep Impact
- Performance and system validation
  - HFSS/PO/PTD/MoM pattern predictions at L-band and S-band
  - L-band design is mature and radar performance is good
  - S-band design is new and has some issues that are starting to be addressed:
    - Significant mutual coupling from S-band patch elements to L-band patch elements
    - Significant degradation is gain (4dB) at near and far-ends of swath (scanning many beamwidths)

Questions